ASSESSMENT ON APPLICATION OF PREFABRICATED CONCRETE STRUCTURAL ELEMENT IN ADDIS ABABAREAL ESTATE CONSTRUCTION

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ASSESSMENT ON APPLICATION OF PREFABRICATED CONCRETE STRUCTURAL ELEMENTSINADDIS ABABA REAL ESTATE CONSTRUCTION

By

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Declaration

I hereby declare that this thesis entitled "**Assessment on the Application of Prefabricated Concrete Structural Element in Addis Ababa Real Estate Construction"** was composed by myself, with the guidance of my advisor, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted, in whole or in part, for any other degree or processional qualification.

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Certificate

This is to certify that the thesis prepared by mis. Kidist Dandir Haile entitled "Assessment on Application of Prefabricated Concrete Structural Elements in Addis Ababa real estate construction" and submitted in fulfillment of the requirements for the Degree of Master of Science complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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ABSTRACT

Real estate industry has been growing fast in Addis Ababa but its cost is prefabrication technology became preferable method in current real estate industry. However, the role of the prefabrication technology in the growing real estate industry of Addis Ababa was not sufficiently studied .The objective of this study, was therefore, to assess the application of prefabricated concrete structural elements in Addis Ababa real estate industry. Descriptive research design and mixed research approach were used. To select representative samples random sampling technique was applied.Primary data obtained using questionnaire and structured interview. Frequency analysis and relative importance index were used to analyze primary data and the result were presented in charts and tables. Accordingly, the study found that almost all professionals have theoretical awareness about prefabrication technology and the majority, 72.5%, of them prefer using prefabrication technology to conventional method of construction, there was lack of information about the existing potential to use prefabricated concrete structural elements and there was shortage of supply of prefabricated concrete structural elements with required shape and dimension. In addition, the research has found that the existing supplier of prefabricated concrete structural element in Addis Ababa has no customer of real estate developer now a day. The research concludes that even if the awareness and preference is available within professionals, there is shortage of supply and lack of information about existing potential. Finally, the research concluded that there is no application of prefabricated concrete structural elements in Addis Ababa real estate construction sector.The researcher recommended that great effort should be done to increase awareness among professionals and other stakeholders. Additionally, establishment of prefabrication plant by the government and investors have to be needed to minimize the shortage of prefabricated elements in addition to improving the existing plant.

Key Words: Prefabrication technology**,** prefabricated concrete structural element, Real estate construction.

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List of Abbreviations

BSC	Bachelor of Science
IMS	Industrial Manufacturing System
MSC	Master of Science
PBPPE	Prefabricated Building Parts Production Enterprise
RII	Relative Importance Index

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Chapter One

INTRODUCTION

1.1. Background of the Study

Prefabrication construction is a construction method by which construction elements are produced fully or partially with special emphasis off-site in a factory and assemble it at site construction. Prefabrication construction has become one of the major mechanism in modern construction industry and majority of building construction consumes prefabricated elements.According to Alireza and Omid (2016) there are several advantages connected with developing and utilizing prefabricated elementswhich include less time and reliance on site labor, easier site inspection, as well as greatly improved design details and quality control. Generally, the method has the ability to have any kind of effect inside different countries construction industry in monetary, social and ecological terms (Alireza and Omid, 2016).

For current fast-growing population, it is essential to have more residential with lesser cost and time. There are several ways by which cost and time reduction is made in current construction industry. One of such a way is using prefabricated structural elements which reduce the overall cost of construction and greatly reduce the construction time.

Addis Ababa is one of the cities with fast growing population and need more residential of low cost and time. According to Samson (2017) a huge gap remains in the housing market, and the needs of the middle-income urban population in Addis Ababa. Furthermore, he argued that real estate developers should go in line with technology advancement and they should learn from the foreigners and come up with something

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new. Accordingly adopting the latest and advantageous construction method is essential for growing real estate construction sector of Addis Ababa. As prefabricated elements are produced under controlled quality with standard and its construction method is needed limited time and lesser cost it is advantageous to address the demand of middle-income population.

This research work aims to investigate the application status of prefabricated concrete structural elements in Addis Ababa real estate construction industry and its potential application. By using literature review, survey questionnaires and interview, analysing the responses about the application of prefabricated concrete structural element by real estate construction in Addis Ababa.

1.2. Statements the of Problem

Now days, in world construction sector using prefabricated elements for real estate construction has been growing. According to David (2014) prefabricated construction is preferred in real estate sector for the reasons that benefits occur right across the value chain to home buyer, the builder and manufacturer.

Real estate development is becoming a very critical and growing sector in Ethiopia specifically in Addis Ababa city. Even though it become critical sector currently there are so many problems in Addis Ababa real construction industry. Samson (2017) states that delays in construction of real estate projects are common in Addis Ababa and its price is not affordable by majority of population. Additionally, it was verified in section 4.2 of the study that the existence of quality problem in Addis Ababa real estate construction especially to concrete structural elements. As time is one of the main factors in construction industry, time over run affects the overall cost of the project by additional

overhead cost, change of material price because of additional time and inflation. As construction method is playing an important role to eliminate those problems and satisfying the growing demand of residence in the city. Adopting using prefabricated concrete structural element is one of the best methods to minimize the quality problem which occurred by poor workmanship and low-quality material, minimize the problems occurred by construction delay and to minimize cost of construction.

There are a number of studies that focus on the plant and the management of overall precast works and its advantage relative to cost and time. Some also focus on the existing organizational structure and history of PBPPE. However, there no research which had done specifically on application of prefabrication technology for real estate construction.

This paper, therefore; aimed to fill the gap of reviewed works by analyzing the application of prefabricated concrete structural elements to real estate construction in Addis Ababa city and its potential to be applied.

1.3. Research Questions

- What is the awareness level about prefabrication technology in Addis Ababa real estate construction industry?
- To what extent prefabricated concrete structural elements are applied in Addis Ababa real estate construction?
- What are the limitations to use prefabricate concrete structural elements for real estate construction in Addis Ababa?

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1.4. Objectives

1.4.1. General Objective

- To assess the application of prefabricated concrete Structural element for real estate construction in Addis Ababa.

1.4.2. Specific Objectives

- To assess level of awareness about prefabrication technology in real estate construction sector of Addis Ababa.
- To assess the current application status of prefabricated concrete structural elements to real estate construction in Addis Ababa.
- To investigate the main limitations to use prefabricated concrete structural elements for real estate construction in Addis Ababa.

1.5. Significance of the Study

This study is significant to Real estate developers, designers and other participants of real estate construction in Addis Ababa to look for the existing potential to using prefabrication construction method. For government and other investors show need and shortage of prefabricated structural elements as an investment area. Also, it will initiate to review practices of the existing plant to improve its supply capacity.

1.6. Scope of the Study

This study focused on the current application status of prefabricated concrete structural elements in Addis Ababa real estate construction industry and its potential to be applied: - awareness of professionals involved in Addis Ababa real estate construction about prefabrication technology, preference of real estate developer and involved professionals to use the method. In addition, this research focused on acceptance of prefabrication

technology in Addis Ababa real estate construction and the future plan of the companies to improve the technology. Geographically the research focused on real estate construction in Addis Ababa city.

1.7. Organization of the Paper

This research paper contains five chapters the first chapter contained the introductory part. It included background of the study, statement of the problem, objective of the study, significance of the study, scope of the study and organization of the paper. The second chapter dealt with the review of related literatures which contain different theoretical and empirical literatures. In the third chapter the methodology of the study is included. The analysis and interpretation are covered in the fourth chapter. Finally, conclusions and recommendations are included in the fifth chapter.

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CHAPTER TWO
REVIEW OF LITERATURE

2.1. Prefabrication Construction

Kariuki (2010) define prefabrication is the practice of assembling elements of a structure in a factory or other manufacturing site and transporting complete assemblies or sub-assemblies to the construction location where the structure is to be placed. Dineshkumar and Kathirvel (2015) also agreed on that the term prefabrication is used to distinguish the process from more conventional construction method of transporting the basic materials to the site where the construction is taking place.

The primary purpose of prefabrication technology is to produce building components in an efficient work environment with accesses to specialized skills and equipment in order to reduce cost and time expenses on the site which enhancing quality and consistency (Anderson and Anderson, 2007).Prefabrication together with increasing use of standardization and mechanization has brought a rapid change in the development of construction field throughout the world. Prefabrication techniques lead to increases large-scale and high-rise constructions (Venkateswara, and Sarath, 2013).

Additionally, Ali and Rahinah (2017) cited the work of Kamar (2001) and defined prefabrication technology as an innovative process of construction using concept of mass-production of industrialized systems, produced at the factory or onsite within controlled environments, it includes the logistic and assembly aspect of it, done in proper coordination with thorough planning and integration.

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2.2. Prefabricated Concrete Structural Element

Prefabricated concrete elements are one of the most remarkable developments in the constructions of concrete structures. They are stated to as signifying that cast in standardized method and given time to harden and acquire strength before being taken to the actual construction site for erection (Venkateswara and Sarath, 2013). According to Bahamon and Bill (2002) using prefabricated concrete structural element is a construction system by in which the essential pieces of structure are sent to the site on which the finished edifice will be constructed partially or completely assembled. Once there, it is necessary only to join and anchor the parts.

Prefabricated concrete allows efficient, economical construction in all weather conditions and provides the long clear spans and open spaces needed. They are prepared, casted and cured at specially equipped plants with a permanent location under standard supervision.Prefabricate concrete is also a popular material for constructing buildings. The walls of the building can be manufactured while the on-site foundations are being built, providing significant time savings and resulting in early occupancy (Venkateswara and Sarath, 2013).

2.3. History of Prefabrication Construction

Ancient Romans have a practice of pour concrete into molds to build aqueducts, culverts and tunnels beginning around 100 B.C. (Mikhailov and Susnikov, 1995). In the 1500's, the timber components of house were crafted and painted in Holland, then assembled in London. Later, the method was widely adopted in Eastern Europe and Scandinavia (Arieff and Burkhart, 2002).

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The Crystal Palace (Giant glass-and-iron exhibition hall in Hyde Park, London) was one of the first prefabrication construction in Britain's during great exhibition of 1851.TheCrystal Palace was constructed in a few months and assembled using a series of prefabricated elements. United States go into the market in the 1900s however the mass fabrication was first introduced in World War II when easy to assemble mass accommodation was required for soldiers (Mikhailov and Susnikov, 1995).

This skill was later utilized by the Europeans and Japanese for quickly rebuild war devastated areas. In the 1960s and 1970s high rise concrete prefabricated construction was introduced (Velamati**,** 2012). Velamati also stated that Hilton Palacio Del Rio Hotel was among the first concrete high rise prefabricated buildings in the world. The project was during the Texas World's Exposition of 1968; the 500-room hotel was designed, completed and occupied in an unpredictable period of 202 working days.

Figure 2.1.Hilton Palacio Del Rio Hotel (Velamati**,** 2012), USA, Texas.

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2.4. History of Prefabrication Construction in Ethiopia

For the first-time prefabrication plant was established in Ethiopia at 1978 E.C with the help of former socialist country Yugoslavia. The company called Prefabricated Building Parts Production Enterprise (PBPPE) and it is the only prefabrication factory in Ethiopia till know. According to Gutema (1998) the aim was to accommodate the ever-increasing demands of housing within the shortest possible time, to overcome the shortage of accommodation and meet the future demands, and to minimize the pressing need of timber for formwork and consequently conserve the natural forest. The Factory primarily in charge of prefabrication - Prefabricated Building Parts Production Enterprise (PBPPE) - has produced structural elements for the construction of office buildings, apartments, hotels and residential buildings for the public and private sector.According to the information from PBPPE, the building shown in the following figure 2.2 is one of those buildings.

Figure 2.2. Mixed Use Building by Prefabricated Elements in Addis Ababa (Helena Building around Lideta) Addis Ababa, Ethiopia.

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The back-log of housing units in Ethiopia was so vast that all efforts made by the Government and inhabitants could not wipe out the shortage of housing in the early 1980s. To promote the building industry and to alleviate the housing shortage prefabrication technology was introduced. The objectives of the enterprise are to promote the building industry through mass production of prefabricated concrete elements, to alleviate the shortage of housing and to reduce the construction cost (Gutema, 1998).

As indicated above establishment of PBPPE in Addis Ababa has brought new techniques for the construction industry and it was supposed to provide the solution for the vast housing needs at the time.

Figure 2.3. Apartment Building by Prefabricated Elements. (Bole Apartments) Addis Ababa, Ethiopia.

2.5. Advantages of Prefabrication Construction

Various literature and researchers have revealed that using prefabrication construction method have so many advantages than conventional method relative to safety, quality, time and cost. Tanya Trainee(2010) specify the main benefits of using prefabricated

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concrete structural elements – the lower construction cost, the speed of construction and the precision of work.

Nadim (2009) also stated that prefabrication technology can be considered as a business strategy that transforms the traditional construction process into a manufacturing and assembly process by embracing new and advanced technologies, engaging people, and translating clients' needs into building requirements. Additionally, Nadim (2012) stated that the advantages of prefabrication method as follow, improving the overall business efficiency, quality of product, environmental performance, sustainability, customer satisfaction, and predictability of timescales. These can be achieved within a controlled production environment, with minimum waste, in a safer work environment, and with better investment in the long-term economy.

2.5.1. Advantage of Prefabricated Elements Relative to Quality

Prefabricated elements were manufactured in a factory environment with better quality control (Jaillon and Poon, 2007).Different mix of prefabricated and cast in-situ elements are used to meet different design requirements for better quality and cost effectiveness. Such combination enables their projects to achieve higher level of productivity than is possible with solely cast in-situ construction (Dineshkumar, 2015). As prefabricated elements were produced in a factory under standard control, quality problems occurred by poor work man problem and low material quality are reduced.

In addition, Architect express that with the use of both prefabricated facades and lost form panels, uniform quality was achieved in the building elevations, and hence promoting continuity in visual quality and aesthetics (Jaillon and Poon, 2007).

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2.5.2. Advantage of Prefabricated Elements Relative to Time

There are various technologies available worldwide for using prefabricated construction methods, almost all technologies try to reduce costs and time, prefabrication method gives possibility to the designers for assembling their structures in a short period of time. There are numerous potential advantages related when delivering and developing building by prefabrication (Alireza and Omid, 2016). One of the greatest benefits is the ability to dramatically reduce the time needed for construction. Factory efficiencies allow building components to be completed quickly and without weather delays. The factory has all of the key player's onsite to handle multiple building requirements and multiple subcontractors are not always required. This makes prefabrication construction suitable for owners who need buildings quickly, properties with hard dates for occupancy, and areas where seasonal weather restricts or even halts construction (Velamati**,** 2012).

As the industry strategies itself to build with less labor and shorter construction time, prefabrication of concrete structures has become a viable alternative to the traditional way of construction.

2.5.3. Advantage of Prefabricated Elements Relative to Cost

The other main benefits of using prefabricated element includes higher financial return due to less construction interest carry and related time savings through a shortened construction schedule and potentially reduced hard cost from repeatable and higher efficiency construction methods, modernised construction process, reduced material waste and higher construction quality (Velamati**,**2012).

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2.5.4. Advantage of Prefabricated Elements Relative to Safety

Prefabricated construction does not only reduce construction costs, but it also produces a more stable and fairly rewarded construction industry with improved safety and working conditions, greater investment in research, design creativity, and product development (Anderson and Anderson2007). Additionally, by using prefabricated concrete elements mainly, on-site operations are considerably reduced, providing a safer working environment (Dineshkumarand Kathirvel,2015).This shows that using prefabricated concrete element have great to minimize work place hazard by minimizing on – site operation and providing safer working condition.

2.5.5. Advantage of Prefabricated Elements to Work Environment

However, it is important to have a good appreciation of its difference in management from the conventional construction. The benefits of using prefabrication would not be fully realized by simply adapting the traditional way of design and construction process. The keys to successful implementation lie in the planning and understanding of the close relationships between design, construction, detailing, execution and manufacturing of precast concrete Components (Dineshkumar and Kathirvel, 2015). In other words, it is vital to have a good cooperation between the architect, the engineer, the builder and the producer. It also reduces consumption of energy and material and generally increases the availability of better designed and high quality-built environments (Anderson and Anderson, 2007).

The adaptation of prefabricated building mainly depends on factors such as labor shortage, labor cost, housing demand, building process efficiency, weather, as well as reduction of waste material and energy consumption. Prefabricated building has a

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relatively inherent economic, environmental, and social benefits (Khaled and Farid, 2015).

2.6. Limitations of Using Prefabrication

Prefabrication technology has not transferred as easily when compared with other technologies because it is a production technology knowledge based and not a consumption technology or product based (Ryan and Shilpa, 2002). It need early decision on design were required in the building process as precast elements were manufactured before delivered to the site for assembly. For architect also, the possibility of late change in the design was limited, client instruction to modification to the design even during construction (Jaillon and Poon, 2007).

Khaled and Farid (2015) also states that the possible barriers to use prefabricated elements as: lack of research information, higher initial construction cost, limited site space, monotone in aesthetics, lack of experience, no demand for prefabrication, inflexible for design changes. Industry practices and techniques, supply chain management and logistics, professionalism of the industry, and construction market risks.

2.6.1. Limitations of using prefabrication technology in Developing Country

Prefabrication technology has not shifted as easily when compared with other technologies because it is a production technology or knowledge based and not a consumption technology or product based. Adapting prefabricated building in these countries is mainly influenced by labor shortage, labor cost, housing demand, building process efficiency, weather, as well as reduction of waste material and energy consumption. Prefabricated building has a relatively low uptake in construction industries worldwide despite its inherent economic, environmental, and social benefits.

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This situation is attributed to prevailing local conditions that vary from country to country. Although motivations in using prefabricated building help determine its use as an option, the decision to implement such technology is influenced by the balance between potential benefits and impediments. The possible barriers to prefabricated building adoption are industry practices and techniques, supply chain management and logistics, professionalism of the industry, and construction market risks.

Further studies should be conducted to investigate the measurement strategies on the application and evolution of prefabricated building. However, addressing prevalent issues in many countries, benefitting from them in enhancing prefabricated building adoption, and avoiding perceived barriers require more extensive approach. The similarities and differences among countries should also be considered. Meanwhile, many other aspects involved in adopting this technology require attention. Transforming the use of prefabricated building into economic rewards requires training, organizational changes, and procurement arrangements in the construction industry.

There are several indications of the potential positive benefits of financial and social incentives, as well as revised national policies and regulations by the government for prefabricated building uptake. Thus, implementing prefabricated building technology requires a complete restructuring of the construction industry. The government should encourage and motivate the private sector to participate in developing such structures (Khaled and Farid, 2015).

2.7. PrefabricationPlant

The product of construction projects has certain requirements assigned to it. These requirements may be imposed by national standards, industrial standards, or it could be

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agreed upon and stated on contract documents. Quality simply means that the project meets these requirements set for it. The accurate meaning of quality for manufactured products for construction is the product satisfies requirements set for it (Halvorsen, 1993).

Quality control is a set of actions taken in order to ensure that products meet the requirements set by purchasers or specifies. QC involves inspection and testing, record-keeping, and being ready to deal with nonconformance in concrete production quality.

Standards help the prefabrication plant to have a minimum level of quality that the products must meet. As a purchaser of materials, the prefabrication should be a 'user' of standards. As a manufacturer, the prefabrication should be a 'producer' of products to the requirements of standards or project specificationsAli and Rahinah (2017).

Quality control professionals could use standards as a measure against which they check whether or not products conform to them. In the case of nonconformance, they can change an input or improve an activity and prevent the below standard product from delivery to clients. Testing and inspection don't add quality to a product. They evaluate a product against established standards and provide the opportunity to correct nonconforming work, and to adjust materials or production before nonconforming products are fabricated" (Halvorsen, 1993)

2.8. Connection Method of Prefabricated Elements of Building

Structural prefabrication is a new construction procedure, which during the last few years has greatly enlarged the potentialities of reinforced concrete. It consists in building a complex structure by connecting prefabricated concrete elements, which collaborate to give structural strength to the whole (Tazeen and Toihidul, 2006).

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Moreover, prefabrication allows the use of elements of complicated shape without construction difficulties or expensive formwork, since each form is used to pour a large number of elements (Vasireddy and A. Venkateswara, 2013). The structural connection between elements is made by welding the reinforcing bars and pouring the joints with high-strength concrete. Old and new concrete elements may be bonded perfectly it the adjacent surfaces are roughened, drenched, and coated with cement plaster before the joints are poured. The weight and dimensions of prefabricated elements must be carefully considered in relation to the mechanical equipment available to lift them into position. Prefabrication usually requires much more accurate and detailed designing than is needed in the construction of a normal reinforced concrete structure (Tazeen and Toihidul, 2006).

2.9. Processes of Prefabricated Building Element Implementation

As it is one of a construction method construction by using prefabrication elements have its recognizable sequential flow. According to Richard (2006) in the initial stage, the prefabricated components are designed according to technical specifications and modular coordination concepts that promote flexibility. Indeed, this flexibility is very important to allow geometrical variations that respond to different needs over space and time.

Subsequently, the components are prefabricated at a factory according to specified dimensions. During this stage, the product or components will be produced repetitively to maximize the output of the factory. The huge number of components produced will provide economies of scale and reduce the operation and investment costs (Riduan, 2012).

The prefabricated components are transported to the site from the factory for the assembly and construction process. At the construction sites, the prefabricated

components are installed with the assistance of lifting equipment. Once installation is completed, the components are ready to be used, even to act as a platform, to support further construction (Bribian, 2009).

Generally, the processes of prefabricated Building element implementation are starting with design, manufacture, construction, maintenance, and finally the demolition activities (Riduan, 2012)**.**

2.10.Current Application of prefabricated elements in Construction

Prefabricate concrete structural building elements are widely used in modern construction industry over worldwide. Being its wide applicability, the total prefabricated concrete buildings systems are becoming a popular choice for many constructions. Prefabricated concrete elements are available in many shape, sizes, including structural elements and unreinforced pieces. The prefabrication industry is the backbone for the development of new ideas in construction business of any country. Factory buildings, residential buildings and the industrial township are needed practically by all the sectors, either to support the manufacturing or services of any industry (Dineshkumarand Kathirvel, 2015).Because of its several advantages using prefabricated element is became preferable method in current construction industry.

Nowadays, different systems of prefabrication technologies are utilized in both developed and developing countries; however, the usage of systems is not the same. In developed countries panel systems are the most common used construction system in prefabricated buildings (Baghchesaraeiand Baghchesaraei, 2015).

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2.11. Current Application of prefabricated Structural Element in Ethiopia

Currently prefabrication technology was applied by limited extent in construction industry of Ethiopia. There is only one prefabrication plant in Ethiopia, Prefabricated Building Parts Production Enterprise (PBPE), which was established 30 years ago without any modification. Kibirt (2017) state that within its 30 years of operation, the Prefabricated Building Parts Production Enterprise has not shown much progress as an organization. It still uses the same outdated batching plant, crane system, and even molds that had been installed during its.

According to Kibirt (2017) the problem here is that with the number of years that have passed since PBPPE has started operation; a lot has changed worldwide in construction technology. What was acceptable 30 years ago may not be up to par currently. Moreover, almost all equipment, forms and design and production manuals that the plant utilizes are the same ones that were put in place during its start almost three decades ago, that all their pages have parched and turned brown. They are very delicately handled as they have not yet been converted and filed into a soft copy format.

The theoretical design capacity of the enterprise was estimated to reach 50,000 meter square of built-up floor area per year, but the maximum attained capacity to date is 33,000 meter square. The production output of the enterprise was designed to build three categories of buildings: the residential buildings up to 5-storeys, and public buildings up to 10 storeys (Gutema, 1998). The types of structural elements produced by the factory include columns, slabs, footings, girder beams, beams, cantilevers, shear walls, stair flights and landings.

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However, majority of the building constructed by prefabrication method in Addis Ababa are public and business building, there are a small number of apartments. The Apartment

Adequate efforts were not carried out to show the merits and demerits of recasting emphasizing the effectiveness and efficiency of pre-fabrication technology as compared to other conventional construction methods. Much has to be done in the future in marketing, and dissemination of information to promote the prefabrication construction in Ethiopia (Gutema, 1998).

2.12.The Current Construction Method in Ethiopian

The construction industry in Ethiopia, like in other developing countries, faces many challenges in its practice. Some of these challenges are project overruns, poor quality, inappropriate procurement systems, and a failure to cope with project requirements and the inability to adopt best practices (Tadesse, Zakaria and Zoubeir, 2016).

The structural elements of the majority buildings in Ethiopia are mainly made of reinforced concrete. As Kibirt (2017) discussed it is common in Ethiopia to build all the structural elements using in-situ methods of construction, where concrete is mixed on site and poured using manual labor. It should also be noted that the in-situ method is done by untrained laborers. An alternative that is being employed in a number of construction sites is employing ready mix trucks to mix and pour concrete. Kibirt (2017) also stated that prefabricated concrete structural element has been utilized in government's building projects more than in private ones.

Reduced formwork and scaffolding strategies are critical in Ethiopia, to reduce both cost and excess timber consumption. The other methods may be considered as "appropriate building technologies" in Ethiopia and may complement a multi-faceted approach to the

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enhancement of vernacular construction techniques. A general problem in the Ethiopian construction industry is the low level of knowledge and experience amongst workers. This contextual condition has a significant negative impact on the industry (Zegeye and Helawi, 2012).

2.13.Real Estate Development

According to Graaskamp (1981) the history of real estate dates back to the evolution of man and his first sedentary shelters. Perhaps it can be called the first attempt to create an enclosed space, which is detached from the surrounding, apparently to protect his family from coldness and attacking animals. Shelter formation enhanced the livelihood of men in terms of protection and gave him longer stability to regularize the surrounding creatively. Miles (2007) also define the term real estate can as, the private ownership of a limited parcel of land, which includes the right of the air above it and the ground below it, and any buildings or structures attached to the ground.

Miles (2007) and Graaskamp (1981) are agreed on that, real estate can exist in the form of business and/or residential properties, which can be sold or either by a relator or directly by the individual who owns the property. Ownership of land is considered as a real property that has sale or transfer right granted by law. Yet, the principle of sale or transfer follows the land policy regulated by the government of a specific country.

Abraham (2007) define residential real estate as, residential real estate is a type of property, containing either a single family or multifamily structure that is available for occupation for non-business purposes. Residences can be classified by, if, and how they are connected to neighboring residences and land. Different types of housing tenure can be used for the same physical type. Connected residents might be owned by a single

entity and leased out or owned separately with an agreement covering the relationship between units and common areas and concerns.

2.14.Real Estate Development in Addis Ababa

The city of Addis is developing and transforming, but still faces a huge backlog in its housing stock that it has to overcome and cope up with in the coming few years. The rate of supply and demand does not match. This increasing growth and development in Addis Ababa represents an ideal situation where the urban phenomena of growth, expansion, and densification can be experienced and investigated. The high demand is creating tension on the construction sector. The city predominantly uses concrete frame and cast in situ constructions (Helawi, 2015).

At this time, private real estate development has been growing in Addis Ababa city. Despite the fact that there is a significantly increase in the production of small family houses year after year the housing price also increases. However; in a developing country like Ethiopia, the increasing cost of living and the earning capacity of population makes home ownership extremely difficult that makes the basic one most luxuries item for low income population (Negash, 2010).

2.15.Current Application of Prefabricated Elements for Real Estate Construction

Prefabricated elements play an important role in the modern world construction of major real estate development today. To meet the high demand, some builders experimented new housing market by creating their own designs and specifications to help build more and faster. Some builders made off-site building components then delivered them to other builders or home buyers rather than building everything at the site. Many were shipped

from the factories, and the result of big benefit has attracted many new investors (Arieffand Burkhart, 2002).

Today, many American homes are made through prefabricated construction methods. Prefabricated construction helps facilitate the American dream of home ownership by offering affordable prices to buyers. “The term prefabricated brings to mind a building system in which the essential pieces of structure are sent to the site on which the finished edifice will be constructed partially or completely assembled. Once there, it is necessary only to join and anchor the parts” (Bahamon and Bill, 2002).

By using prefabricated concrete structural element, benefits occur right across the value chain. The home buyer benefits through a reduced build time, increased time and cost certainty and through improved value for money and fewer defects. The builder, large or small, benefits through fewer weather disruptions, and when demand for building services is high, is able to complete more projects per year. The manufacturer increases the opportunities to add more value and increase profits on-site (David, 2014). Today, prefabricated construction attracts real estate developers for the same reasons. During prefabrication method the speed at which buildings can be constructed has obvious reducing costs and facilitating higher volumes of construction (Tanya and Trainee, 2010). These benefits have particular relevance to countries which have high demand of residence is currently facing a shortage in the supply of homes such as Ethiopia especially in Addis Ababa.

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CHAPTER THREE
METHODOLOGY

Methodology is a plan of action that shows how the problems are investigated, what information are collected using which methods, and how this information is analyzed in order to arrive the conclusions and to develop recommendations. To obtain its objective, this research paper was follow sequential steps illustrated in the figure 3.1.

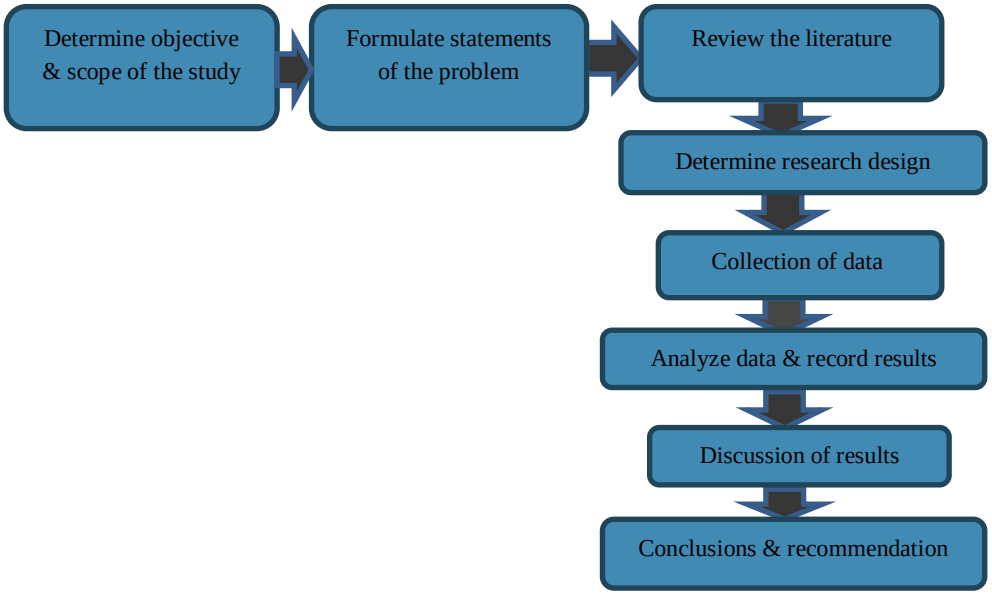

Figure 3.1. Design of the research

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3.1. Research Approach

Johnson and Harris (2002) described that, research approaches can be broadly categorized as either quantitative or qualitative. Quantitative research is objective in nature and it usually requires respondents to record their attitudes, opinions, or beliefs on different-point scale measured with numbers (Krosnick & Presser, 2010). On the other hand, qualitative research is subjective in nature (Naoum, 2007). It relies on observing people in their own environment, communicating with them in their own language, and on their terms.

According to Creswell (2009) a research study using both qualitative and quantitative approaches can be called a "mixed-methods" approach. In addition, Creswell (2009) identified thatusing mixed methods provide strengeths that offset the wekneess of both qualitative and quantitative strategy and it provide more comprehensive evidence of reserch problem either using qualitative or quantitative strategy alone. Accordingly, both qualitative and quantitative research approach were adopted to undertake this research. It has a qualitative approach when it deals with the qualitative data, and quantitative approach when it deals with quantitative data.The data gathered by interview was analyzed by qualitative approach. Whereas the data gathered through questionnaire was analyzed by quantitative approach.

Target Population

The population of the study consisted of all real estate developer in Addis Ababa and suppliers of prefabricated concrete structural elements in Addis Ababa. According to the data from ministry of trade, the total number of real estate developer that had been currently

licensed were 209.And only one supplier of prefabricated concrete structural elements in Addis Ababa.

3.2. Selection of Samples

This research was use random sampling which is the purest form of probability sampling for data analyzed by quantitate method and Purposive sampling for data analyzed by qualitative method. Probability sampling was applied to quantitative based study (Saunders, Lewis and Thornhill, 2009).They also state that, in probability sampling each member of the population has an equal chance of being selected it is a major issue before a researcher headed to collection of data. The size of sample should neither be excessively large nor too small, it should be optimum. An optimum sample is one which fulfills the requirements of efficiency, representativeness, reliability and flexibility. While deciding the size of sample, researcher must determine the desired precision as also an acceptable confidence level for the estimate. Sample size can be calculated as the following equation for 96% confidence level (Assaf, 2001):

$n_a = n_r / [1 + (n_r/N)]$

Where n_a= the adjusted sample size, n_r= the original required sample size and*N* = population size. Population elements and V is a standard error of sampling population. (Usually S = 0.5 and V = 0.06).

1. Real estate developer sample calculation

$n_a = n_r / [1 + (n_r/N)]$

$n_a = S^2/V^2 = (0.4)2/ (0.06)2 = 44.44$

Population (N) = 209Real Estate Developers

$n_r = 44.44 / [1 + (44.44 / 209)] = 36$

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This implies the questionnaire should be distributed to 36 real estate developers in order to achieve 96% confidence level.

2. Professionals sample

After determining number of Sample Company, currently active companies are selected purposively. The selected company was represented by one representative person from head office and by one most active site. The total number of engineering professionals participated on the selected sample projects were included. To increase the precision and quality of data collected all professionals who participate in selected project were allowed to participate in the questionnaire survey which include professionals with position site engineer and above. The number of professionals in selected project were indicated in the following table 3.1.

Table 3.1. Number of questionnaire distributed with respect to each respondent group

Organization	Consultants	Real Estate Developer	Contractor	Total
Questioner distributed	40	82	57	179

3.3. Method of Data Collection

Selection of data collection method depends on different factors such as nature and scope of investigation, availability of fund, time needed and precision required. The type of research and data needed dictate what type of data collection methods to be used (Saunders, Lewis and Thornhill, 2009). According to Denscombe (2007) a questionnaire allows large populations to be surveyed more efficiently than other instruments. Accordingly, for this research paper questionnaires survey was used to collect data from professionals in Addis Ababa real estate construction because of that it is relatively

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contain large population. And semi structured interview was selected to collect primary data from supplier to achieve the objective of the research.

3.4. Data Collection Procedure

The fundamental rationale for collecting data is to allow the researcher to gather enough evidence and consequently draw the interpretations required to make important decisions about the findings (Alex, Julus and Vian, 2016). Prior to collecting data using questionnaire and structured interview, valuable information was obtained from literature review. Based on the acquired facts questionnaire has been designed. The designed questionnaire was significantly helped to improve the quality of the questions and improved its clarity to be understood by all participants. Questionnaires were sent to 179professionals who had been engaged on the sample projects. Out of 179questionnaires distributed to real estate developer, consultant andcontractor166 responses were received with 92% return rate. Furthermore, some data were collected from the sole supplier, Prefabricated Building Parts Production Enterprise, by interviewing the managers and professionals at engineering department.

3.5. Data Reliability

Saunders, Lewis and Thornhill (2009) defined the reliability as an instrument of the degree of consistency which measures the attribute it is supposed to be measure. The lesser the variation an instrument produces in repeated measurements of an attribute, the higher its reliability. Reliability can be equated with the stability, consistency or dependability of a measuring tool. Reliability of the data was insured by testing the questionnaires prior to distribute to the planned respondents.

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3.6. Data Validity

Validity refers to the degree to which an instrument measures what it is supposed to measure (Pilot &Hungler, 1997). Validity has a number of different aspects and assessment approaches. Statistical validity is used to evaluate instrument validity, which include criterion-related validity and construct validity.

Data Analysis

Analysis of data collected by questionnaire survey was undertaken using micro soft excel tool. Frequency tables and descriptive statistics were constructed to display results with respect to each of the questions of general information and application factor. Percentages are easier to interpret and, in this analysis, they are implemented to express the findings as a proportion of the whole. The findings are presented in the form of tables and charts to help understand easily.

The Likert scale data was analyzed using relative importance index (RII) method. RII method was used herein to ordinals arranges variables in terms of importance and agreement to determine professionals' perceptions of the relative importance of the identified application factor. According to (Cheung and Suen, 2004) the RII was computed as: -

$$RII = \frac{\sum W}{N*A}$$

Where

W is the weight given to each factor by the respondents and ranges from 1 to 5;

A – The highest weight = 5 in this case;

N – The total number of respondents

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The data collected from supplier, Prefabricated Building Parts Production Enterprise by interview was analyzed by qualitative method. It concerns the current supply status of prefabricated concrete structural elements.

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CHAPTER FOUR

ANALYSIS, RESULTS AND DISCUSSIONS

4.1. Introduction

This chapter focus on analyzing and interpreting the result gathered from the respondents through questionnaire and interview. Based on the gathered data from the respondent's current application status of prefabricated concrete structural elements in Addis Ababa real estate construction and its potential application were analyzed. The result was interpreted based on information from personal interview with the respondents and questionnaire survey data.

4.2. Verification for the Existence of Quality Problem

To verify the existence of quality problem in Addis Ababa real estate construction during construction of concrete structural elements. Respondents were asked if there was deviation on quality of concrete structural elements from standard, design and specification in their project, and their confirmation was reported on figure 4.1 below.

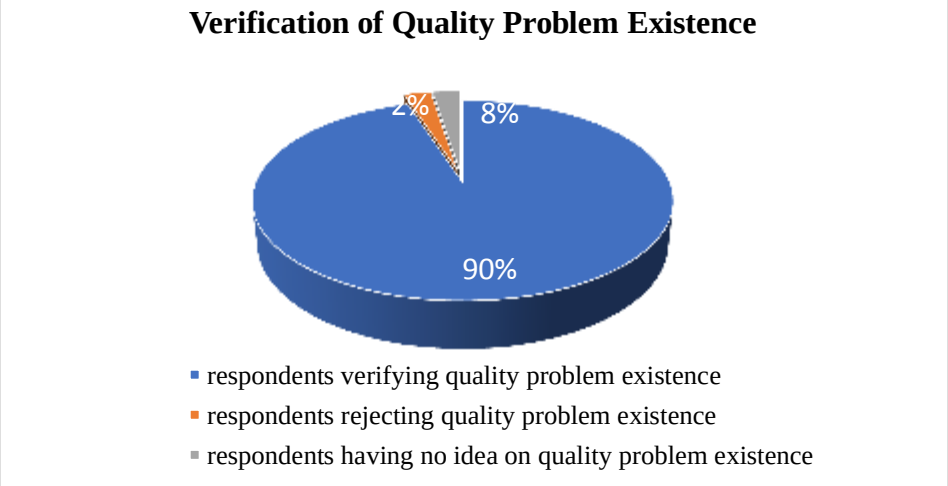

Figure 4.1. Respondents' opinion on the existence of quality problem

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Regarding quality problem 8% of the respondents verify that there is no quality problem on their site during construction of concrete structural elements. 90% of the respondents assure that there is a problem on construction of concrete structural elements while the others 2% have no idea on existence of quality problem.

4.3. General Respondents' Characteristics

Under these section characteristics of selected respondents was presented. Which included: - current position of respondents in the organizations, their educational background, and their work experience in real estate projects.

With first question of this section, respondents were asked the type of company they working at and their response was reported as follow.

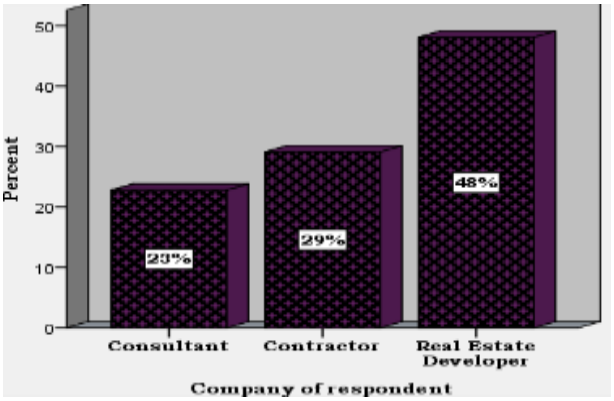

Figure 4.2. Organizations of Respondents

As it can be observed from Figure 4.2 above the distribution of the response wascontractor (29 %), Consultants (23 %) and real estate developer (48%).

Regarding the position of respondents in real estate construction sector the indicating question was raised to respondents and the result was presented here. The result shown from figure 4.3, among the total22%, 18% and16% of participants were site engineers, supervisor and project engineers respectively. The majority of respondents were office

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engineer, 32 %, and the remaining 7% and 5% are project manager and design engineer respectively.

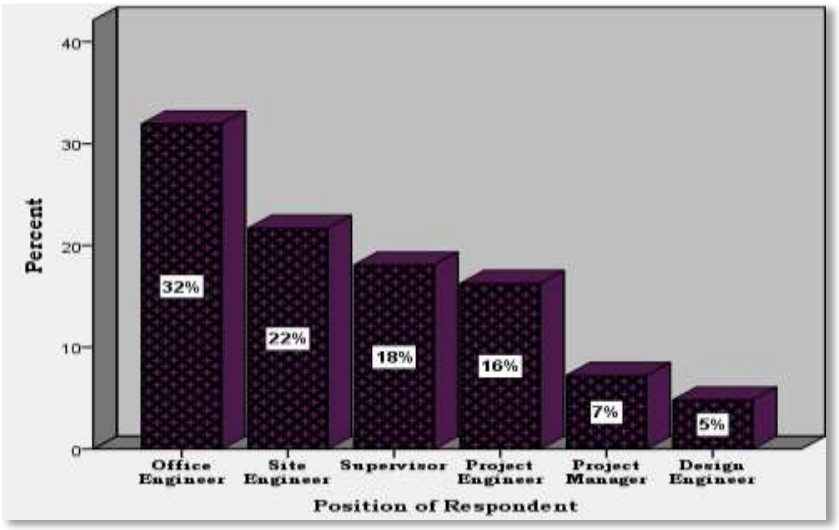

Figure 4.3.Respondents' Current Position

The experience years of respondents was reported with the figure 4.4 below. In the figure below which shows the results about work experience of respondents; 38% of the respondents have 5-10 years of experience, 36% have an experience above 10 years and the rest 26% have an experience less than 5 year.

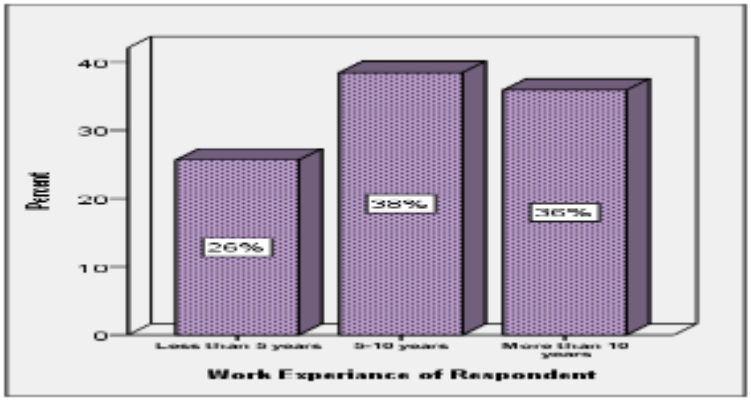

Figure 4.4. Respondents' experience in real estate construction

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The study also considers respondents educational background; accordingly, the survey result was revealed thatthe majority of participants, 76%, have educational qualification of first degree. Whereas the 24% of participants were having educational level of second degree as observed from figure 4.5.

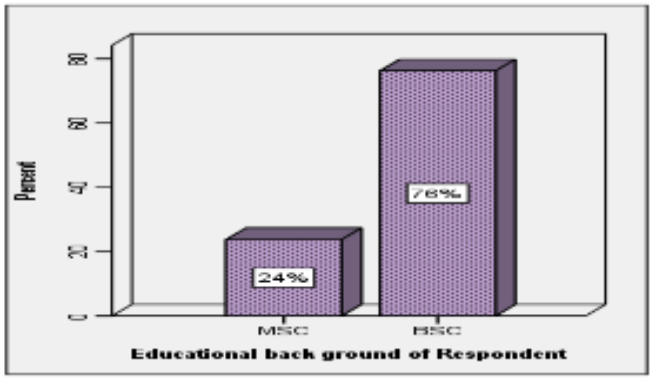

Figure 4.5. Educational background of respondent

4.4. Awareness and Preferences of Prefabrication Technology

This section aimed to analyse the awareness of professionals who participate in real estate construction of Addis Ababa about the existing potential to use prefabricated technology for real estate construction in the area and their preference to use it.

Accordingly, respondents were asked about their awareness about prefabrication technology through Yes/No question and the result was reported in Table. 4.1 Below.

Table 4.1. Awareness of respondent about prefabrication technology

Do you know about prefabrication technology?	Frequency	Percentage
Yes	166	100%
No	0	0%

As indicated on the report table 4.1 all respondents, (100%), answer yes for the above question. The above result shows that all professionals have an awareness about prefabrication technology theoretically.

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In this research, the awareness of professionals in Addis Ababa real estate construction about prefabrication technology was evaluated relative to literature reviewed from different sources. Accordingly, to evaluate outlook professionals about advantages of using prefabrication technology than in situ construction method, the following factors were identified from literature review and respondents were asked their opinion. And the result was presented in the table 4.2.

Table 4.2.Advantages of using prefabricated technology ranked by all respondent

Advantages	Mean	Standard deviation	RII	Rank
It takes shorter time	4.86	0.466	0.97	1
Minimize material wastage	4.86	0.466	0.97	1
Minimize quality problems	4.86	0.466	0.97	1
Minimize overhead cost	4.71	0.614	0.94	2
Minimize work place hazard	4.67	0.691	0.93	3
Easy HR management	4.62	0.71	0.92	4
Low maintenance cost	4.13	0.706	0.83	5

The result shows that professionals perceived that: - it takes shorter time, minimize material wastage, minimize quality problems are ranked first with RII=0.97. Minimize overhead cost; RII 0.94, minimize work place hazard; RII=93, easy HR management; RII= 0.92, are ranked second, third, and fourth respectively. Whereas low maintenance cost is ranked fifth with 0.83 RII.

The rank and RII value of advantages of prefabrication technology ranked by Real estate developer, contractors, and consultants was reported in the Tables A, B, and C in the appendix C respectively.

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Accordingly, the ranking of the major advantages of using prefabricated structural elements were similar among all respondents; and more than one factors have similar rank by all category of respondent parties. This result shown that respondents agreed on that the above factors are the main advantages of using prefabricated structural elements over conventional method. The result agreed with Velamati (2012) who identified that benefits of using prefabricated elements are: - higher financial return due to less construction time and reduced material waste and higher construction quality. Moreover value of standard deviation was less than one for all factors which implies that there is no variation between the opinions of professionals towards the advantages of using prefabrication elements.

The study also considers the shortcomings of using prefabrication technology during assessment of awareness of professionals about the technology and respondents were asked their opinion about shortcoming factors which identified from literature review.

Table 4.3.Shortcomings of using prefabricated technology ranked by all respondents

shortcomings	Mean	Standard deviation	RII	Rank
It is not flexible with design	4.73	0.57	0.95	1
Not easily transported	4.72	0.59	0.94	2
It may face connection problem	4.58	0.72	0.92	3
It need more expensive machinery	4.52	0.74	0.9	4

Table 4.3 shows that the RII value of shortcomings of using prefabricated structural elements ranked by all respondents. The result indicated that, the main shortcoming of using prefabricated technology ranked first was: - it is not flexible with design with RII value of 0.95. Not easily transported was ranked as second and have RII value of 0.94. It

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may face connection problem and it need more expensive machinery put in the third and fourth rank with RII value of 0.92 and 0.90 respectively.

The rank and RII value of Shortcoming factors of prefabrication technology ranked by Real estate developer, contractors, and consultants was reported in the Tables D, E, and F in the appendix C respectively.

Moreover, the ranking of the limitation of using prefabricated technology was different according to different perception of respondents by the category of respondent parties. For instance, it is not easily transported was ranked first by contractor, second by real estate developer and third by consultant. This implied that the main problem for one party might not be the same for other. Besides, the survey data indicated, the level of agreement might different among the individual parties towards the shortcoming factors. Even if their degree of agreement was varied, all respondents were agreed on the above limitations.

Additionally, respondents were asked to specify if there are other shortcomings of using prefabricated structural elements, factors they specified are listed below according to their order of frequency.

- It minimizes job opportunity of citizens

This result also agreed with the findings of Jaillon and Poon (2007) also argued that inflexibility for design change, transportation problem in a dense urban environment are limitations of using prefabrication technology.

The result of the analyses of the above two sections point out that there is awareness of prefabrication technology among professionals in Addis Ababa real estate construction

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industry. For the reason that the RII value for all factors included in advantage and shortcoming section was greater than 0.8. This implies respondents agreed on all factors even if their degree of agreements varied from factor to factor and those factors were derived from deferent literature about the technology. And the value of standard deviation was less than one for all factors which implies that there is no variation between the opinions of professionals towards the challenges of using prefabrication elements.

Next to awareness, preference of a given technology in a given area has a significant role for application and improvement of the technology within the area. Preference of the professionals and stockholder of real estate construction in Addis Ababa is one of a greater potential to use prefabrication technology in the sector. To evaluate the preference of professionals to use prefabricated technology, respondents were asked to select weather they prefer prefabrication method or cast in situ method through Yes/No question and also to justify their reason for their answer. The result is reported in Fig. 4.6 below.

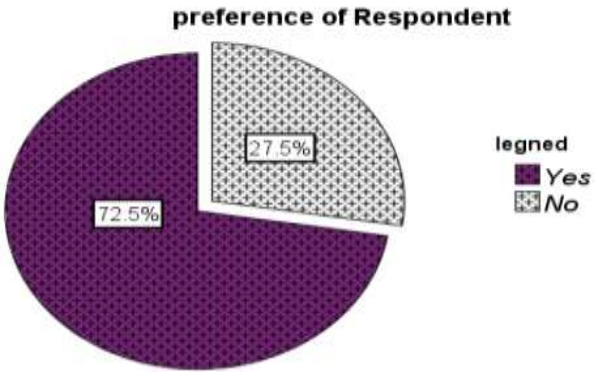

Figure 4.6.Preference of respondent to use prefabrication method

As indicated on the report graph, the number of respondents that prefer using pre-fabricated elements is dominates, that is 72.5% of the total respondents. The result shows

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that majority of professionals in Addis Ababa real estate construction prefer to use prefabricated element than conventional method. Therefore, this acceptance is a potential to apply the technology in Addis Ababa real estate construction industry. Likewise, Harvey (2011) justify that demand of stake holders to use prefabricated element is a key derive to usage.

As indicated in literature review, there is only one prefabrication plant in Addis Ababa, the Prefabricated Building Parts Production Enterprise. To investigate the information of the professionals about the plant and its production capacity respondents were asked whether they know the availability of the factory and also its production capacity. The result is described in figure below: -

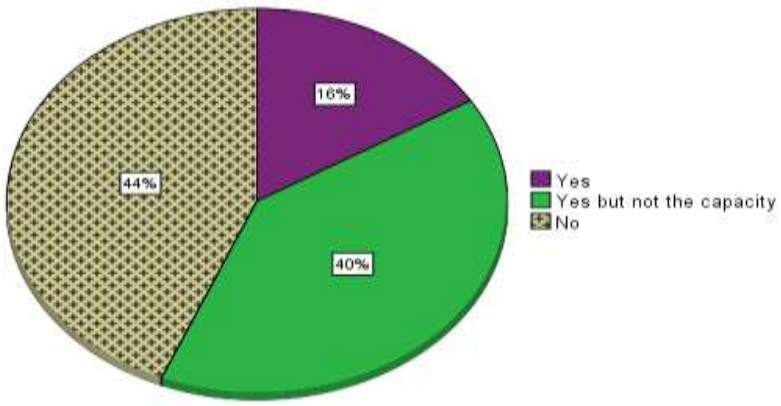

Figure 4.7. Information of respondent about existing prefabrication plant

The above Figure 4.7 shown that 44% of the respondents have no idea about prefabrication plant in Addis Ababa, whereas 40 % knew the presence of the prefabrication plant in Addis Ababa but not its capacity. While 16% of the respondents were answer yes which means they know the existence of the plant and its capacity of production also.

This result implies that there is a lack of information about the prefabrication plant within professionals in Addis Ababa real estate construction, PBPPE, to consider prefabrication construction method as one option during preliminary and design stage of construction. Gutema (1998) also argued that the available precast structural elements are not made well known to design offices in the country through publications, commercial advertisement in order to promote their use in the industry.

4.5. Application of Prefabricated Concrete Structural Elements to Real Estate Construction in Addis Ababa.

The main objective of this section was to analyse the current level of application of prefabricated concrete structural element to real estate construction in Addis Ababa. And also, to investigate the potential of prefabrication technology to be applied to the industry. This section includes the current existing potential and consider actions to be taken to improve the application of the technology in future.

To examine the experience of professionals on prefabrication technology, respondents were asked if they would have an experience on prefabrication construction method. The result shows that 87.5% of respondents have no experience on prefabrication technology, while 12.5% of respondents have an experience on prefabrication construction method, but it was not on real estate construction.

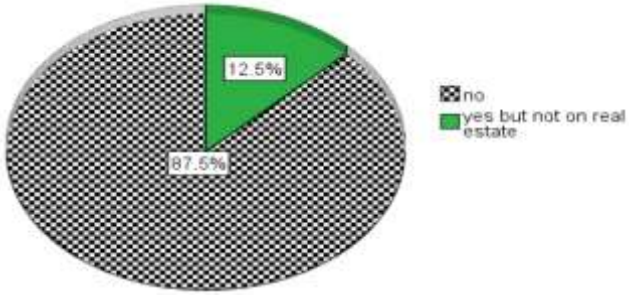

Figure 4.8. Experiences of respondents on prefabrication technology

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To investigate the application of prefabricated concrete structural elements in Addis Ababa real estate construction, respondents were asked that if their company have any work experience on prefabricated structural elements.

Table4.4. Companies experience on prefabrication construction

Does your company have any work experience on using prefabricated structural elements during real estate construction?	Frequency	Percentage
Yes	0	0%
No	97	58%
I don't Know	69	42%

The result of the analysis reported in table 4.4 indicates that 58% respondents were answer that their company have no experience on using prefabricated concrete structural elements while 42% of them answered that they don't know whether their company have work experience on using prefabricated concrete structural elements or not. But no one answer that their company have an experience on prefabrication construction.

To assess the future plan of companies who participate in real estate construction to improve the application of prefabrication technology by establishing prefabrication plant, respondents were asked if their company have any plan to establish prefabrication plant in Addis Ababa and also to specify their reason if their answer is No. The result was reported in Fig4.9. Below.

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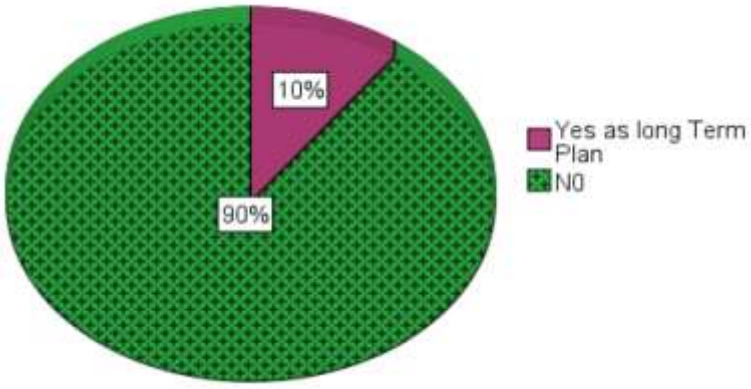

Figure 4.9. Need of prefabrication plant to established in Addis Ababa

As indicated on the report graph thesurvey result was revealed that, number of respondents that no plan to establish was dominates, (90%) of the total respondents. The remaining 10 % of the respondents said that they have a long-term plan.

For respondents who answer that they have no plan to establish prefabricated plan, reasons they specified are listed below according to their order of frequency: -

– It economically unaffordable for the company.

– There is no practice to use prefabrication technology in Addis Ababa to get customer.

4.6. Challenges to Use Prefabricated Concrete Structural Elements to Real Estate Construction in Addis Ababa

This part aims to investigate the challenges in Addis Ababa real estate construction to use prefabricated concrete structural elements. A final list of factors ordered according to their significance. The results of this part of study provide an indication of the relative importance index and rank of factors affecting the application of prefabrication technology to real estate industry in Addis Ababa.

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Table 4.5. Challenges to apply prefabricate structural elements ranked by all respondent

Factors	Standard deviation	Mean	RII	Rank
Shortage of supply of prefabricated elements	0.47	4.86	0.97	1
Lack of information about the existing potential	0.59	4.72	0.94	2
Shortage of skilled man power on the area	0.9	4.46	0.89	3
Lack of willingness of professional	0.52	4.08	0.82	4

Even though, respondents were asked to specify if there are others additional challenges to use prefabricated structural elements in their company, nothing mentioned.

As indicated by the result of the analysis shown in the above Table 4.5 respondents agreed on that, Shortage of supply of prefabricated elementswas the factor highly affect the application of the prefabricated structural elements in Addis Ababa real estate construction. For the reason that it was ranked first with relative importance index value of 0.97. Next to shortage of supply of prefabricated elements, lack of information about the existing potential was ranked second with relative importance index value 0.94. And lack of awareness about the technology and lack of willingness of professionals stood third and fourth with relative importance index value 0.89 and 0.82 respectively.

The result of the analyzed survey data reported in the tables on Appendix C (Table G, H and I) shows that real estate developer and consultant gave the same rank for all factors while contractor ranked them differently expect that the shortage of supply of prefabrication elements which ranked first by all respondents.

The result shows that shortage of supply of prefabrication elements, lack of information about the existing potential, shortage skilled man power on the area, lack of consideration of the existing dimension during design and low motivation of designers to adjust their work with it are the major challenges to apply prefabricated structural

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elements in Addis Ababa Real estate construction. Moreover value of standard deviation was less than one for all factors which implies that there is no variation between the opinions of professionals towards the challenges using prefabrication elements.

There are deferent types of organisations participate one real estate construction such as real estate developer, designers/consultant, contractorand so on. Those firms have different role in the sector so that their influence on improvement of real estate technology in the sector also deferent. In regard to firm's potential to improve the application of prefabrication technology in real construction of Addis Ababa the respondents were asked their opinion. The results of the report of the respondents was given in Table. 4.6.

Table 4.6. Potential of firms to change the sector

Factors	Mean	Standard Deviation	RII	Rank
Government	4.90	0.36	0.98	1
Real estate Developers	4.72	0.59	0.94	2
Designers	4.45	0.85	0.89	3
Contractor	4.72	0.82	0.8	4
Client	3.00	1.10	0.6	5

As the result indicate, the more influential firm to improve the application of prefabricated concrete structural element in Addis Ababa real estate construction among the stakeholders were ranked by all respondent parties as follow.

Real estate developer perceived that Government; RII=0.97, designers; RII=0.87, real estate developers; RII=0.73, contractor; RII=0.71 and client; RII= 0.41 are most influential firms respectively. Consultants perceived that the potential of firms to change the sector are: Government parts; RII=0.97, real estate developers; RII=0.86, designers;

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RII= 0.76, contractor; RII=0.73, and client; RII= 0.42. While contractor perceived that Government; RII=0.96, designers; RII=0.89, real estate developers; RII=0.81, contractor; RII=0.71 and client; RII= 0.55 are the most influential firms respectively.

This result revealed that even if government have high potential to improve the application of prefabricated structural elements in Addis Ababa real estate construction, all parties have influence while the role of client is low. Likewise, Alireza and Omid (2016) argued that implementing prefabricated building technology requires a complete restructuring of the construction industry. So that government should encourage and motivate the private sector to participate in developing such structures. Moreover value of standard deviation for client was greater than one which implies that there is variation between the opinions of professionals towards the clients influence to improve the sector using prefabrication elements.

4.7. Analysis of Agreement Spearman's rank Correlation

The Spearman's rank correlation coefficient (ρ) was used to show the degree of agreement between the rankings of any two parties. The Spearman's rank correlation is a non-parametric test. Non-parametric tests are also referred to as distribution-free tests. These tests do not require the assumption of normality or the assumption of homogeneity of variance. They compare medians rather than means and, as a result, if the data include one or two outliers, their influence is excluded and ρ value between 0.8-1 shows very strong agreement between respondents. (Chia-Cheng and Huiman, 2013). The Spearman's rank correlation coefficient (ρ) was calculated as follows:

$$\rho = 1- \frac{6\sum d^2}{n\,(n^2-1)}$$

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Where:

d = the difference between the ranks given by any two respondents for an individual cause and

n = the number of groups.

4.6.1 Agreement Analysis on advantages of prefabrication technology

Agreement analysis is on advantages of prefabrication technologybetween real estate developer and contractors, real estate developer and consultants, and consultants and contractors are shown in the tables A, B, and C of Appendix D respectively.

The correlation coefficients value for advantages of prefabrication technology are 0.91, 0.91, and 0.88 for real estate developer and contractors, real estate developer and consultants, and consultants and contractors respectively. This shows that high agreement between rankings because ρ value between 0.8-1 shows very strong agreements between respondents.

4.6.2. Agreement Analysis on shortcomings prefabrication technology

The agreement analysis on shortcomings prefabrication technology between real estate developer and contractors, real estate developer and consultants and consultants and contractors are shown in the tables D, E, and F of Appendix D respectively.

According to the correlation coefficients obtained from survey data, real estate developer and contractors are 0.91, real estate developer and consultants 0.80, and consultants and contractors 0.90 agreed on shortcomings of using prefabricated technology.

4.6.3. Agreement Analysis on challenges of using prefabricated concrete structural elements in Addis Ababa real estate construction

The agreement analysis on challenges of using prefabricated concrete structural elements in Addis Ababa real estate construction between real estate developer and contractors, real

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estate developer and consultants and consultants and contractors are shown in the tables G, H, and I in Appendix D respectively.

According to the correlation coefficients obtained from survey data, real estate developer and consultants 0.90 agreed on challenges of using prefabricated concrete structural elements in Addis Ababa real estate construction. In the other side, correlation coefficients forreal estate developer and contractors0.70, and for consultants and contractors 0.40 which means that they are moderately agree on that the proposed factors may challenges the use of prefabricated concrete structural elements in Addis Ababa real estate construction.

4.6.4. Agreement Analysis on most influential parties to improve prefabrication technology

The agreement analysis on most influential parties to improve prefabrication technologyin Addis Ababa real estate construction between real estate developer and contractors, real estate developer and consultants and consultants and contractors are shown in the tables J, K, and L in Appendix D respectively.

Real estate developer and contractors, real estate developer and consultants and consultants and contractors have the same correlation coefficients ρ value 1. This shown that they were strictly agreed on influential order of stakeholders to improve the application of prefabrication technology in Addis Ababa real estate construction.

4.7. Findings and Analysis of the Interviews

For more information and better understanding on the application of prefabricate concrete structural elements interview was conducted with employees of Prefabricated Building Parts Production Enterprise (PBPPE). In order to investigate the potential of PBPPE to

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supply prefabricated elements for real estate construction and the future plan of the company to involve in the sector semi structured interview questions are raised to the PBPPE Staff members. The results gained from the interview were discussed under this section.

Regarding the investigation of the application of prefabrication technology in real estate construction of Addis Ababa, respondents were asked if they have any customer of real estate developer or real estate contractor. According to the data from the respondents at present PBPPE have no customer from real state participant in Addis Ababa. Recalling that PBPPE was the only supplier, this data revealed that prefabricated concrete structural elements was not applied in Addis Ababa real estate construction.

To investigate challenges of the factory to participate in real estate construction in Addis Ababa respondents were asked their opinion, and their responses are listed below according to their order of frequency: -

1. The existing plant is producing structural elements with only limited shape and size.
2. Designers are not considering the potential of existing plant during design stage and their willingness to adjust their work which was very low.
3. There was no culture of using prefabrication technology in Addis Ababa real estate construction sector.
4. The company it selves not made any promotion work to enter in the real estate industry because of that its production capacity was limited to search for additional customer.

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Regarding the future plan of the company towards the real estate industry respondents were asked their opinion as the management part of the company. The result from the respondents revealed that the company have plan to improve production the capacity of the existing plant and to increase item of its products. Additionally, to make a complete industrialized building the company have planned to produce standardize window and door in addition to the structural elements of building. The respondents are also state that, real estate sector is the main target area in the future expansion plan of the company.

For the last interview question, about need of major renovations for PBPPE plant, all respondents are believing that the factory need renovation and stated that it is one of the future plans of the company.

4.8. Summary of Findings and Analysis

The purpose of this section is to pinpoint the major findings of the study which found by analysis of both the surveys data and interviews. Summary of observation obtained from the study was presented below in each category.

4.8.1. Awareness and Preferences of Prefabrication Technology

The research finds that all professionals in Addis Ababa real estate construction have awareness about prefabrication technology theoretically. Regarding the advantages and disadvantages of using prefabricated elements factors are derived from literature about the technology, all respondents agreed on them with RII value greater than 0.90which implies that they have awareness about prefabrication technology.

Additionally, the research find out that 72.5% of the professionals in Addis Ababa real estate industry prefer to use prefabricated element than conventional method. The final

finding of this section was: - that the majority of professionals in Addis Ababa real estate construction have no information about the existing prefabrication plant within, PBPPE.

4.8.2. Application of Prefabricated Concrete Structural Elements to Real Estate Construction in Addis Ababa

Regarding the application of prefabricated concrete structural elements in Addis Ababa real estate construction, there are no professionals who have an experience on using prefabricated structural elements in real estate construction. And there is no company which presently apply prefabricated concrete structural elements.

In addition, the research finds that the only supplier of prefabricated concrete structural element, PBPPE, currently have no customer of real estate developer. Depending on the above factor the researcher concluded that currently there is no application of prefabricated concrete structural elements in Addis Ababa real estate construction.

4.8.3. Challenges to Use Prefabricated Concrete Structural Elements to Real Estate Construction in Addis Ababa

In this section the research found that the shortage of supply of prefabrication elements, lack of information about the existing potential, shortage skilled man power on the area, lack of consideration of the existing dimension during design and low motivation of designers to adjust their work with it are the major challenges to apply prefabricated st**r**uctural elements in Addis Ababa Real estate construction.

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CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

The main objective of this research was to investigate the application of prefabricated concrete structural elements for real estate construction in Addis Ababa. In order to accomplish that objective, it was necessary to reach some prerequisite goals. The research has shown to determine the level of acceptance that the real estate construction sector has the prefabricated construction system. Related to that effort, it became necessary to reach an understanding about the nature of real estate construction method. To provide the possibility that prefabricated construction could be perceived and measured as a viable method for the booming real estate business; this chapter reports the conclusions and recommendations that resulted from this study.

5.1. Conclusions

- Even if the general theoretical idea of prefabrication technology is known by professionals involved in real estate construction in Addis Ababa, majority of them have no information about the existing prefabrication plant in Addis Ababa.
- Majority, 72.5%, of the professionals involved in Addis Ababa real estate construction are preferred using prefabrication construction method to conventional method. But it is believed that there is no capability to use the technology in construction industry of Ethiopia.
- There is no sufficient supply of prefabrication elements in Addis Ababa, as a result the attitudes towards use it for real estate construction is also limited. The study

shows that, currently there is no practice of using prefabricated concrete structural elements in Addis Ababa real estate construction.

- The major challenges to use prefabrication technology are: - shortage of supply of prefabrication elements, lack of information about the existing potential, shortage of skilled man power on the area, lack of consideration of the existing dimension during design and low motivation of designers to adjust their work with it.

5.2. Recommendations

Based on the findings of the study and the discussions above a summary of some general recommendations are offered to support the improvement of application of prefabrication technology for real estate construction in Addis Ababa and to recommend some area for further investigation. These are listed below:

- Great effort should be done by government to distribute technical information for professionals and other stakeholders to raise public information about the existing potential of the technology.
- Acceptance and preference of the technology by professionals is great potential to apply a given technology, so that the government and other stakeholders should use this resource as an input.
- To minimize the shortage of supply of prefabricated elements in addition to improving the existing plant, government should encourage the investors who have potential to establish modern prefabricating plant in Addis Ababa.

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- The government should pay due attention to develop prefabrication construction as a viable solution to improve the quality, speed, and economy of upcoming real estate construction.

5.3. Recommendations for further study

The researcher believes a further work on this area is vital in order to improve the application of prefabricated structural elements in Addis Ababa real estate construction.

- ❖ The capacity of companies in Ethiopia to establish modern prefabrication plant.
- ❖ The effect of using prefabricated elements on unemployment.

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Appendix A - Questionnaire

Dear respondent", I am Student of Masters of construction Technology and Management, (COTM), at **Addis Ababa Science and Technology University**. As partial fulfilment of the program, I am undertaking a research on the topic of **Assessment on Application of Prefabricated Concrete Structural Elements for Real Estate Construction in Addis Ababa**.

Therefore, I hereby would like to request you voluntarily take some of your valuable time and assist my research project by filling the attached questionnaire in the time being. It is believed that your participation in this research will contribute in achieving the objectives of the research. Thus, the quality of your response towards the question items determines the quality of the research results. If you do have any questions about the study, please do not hesitate to forward it at the addresses stated below.

Note That: -

- I want to assure you that all information provided in this survey will be treated with strict confidentiality and allowed to serve only for the purpose of the research under consideration.

With my best regards,

KidistDandir

Email: kidistdir@gmail.com

Addis Ababa, Ethiopia

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Section I: -General Respondents' Characteristics

1. Type of organization you are working for?

□ Real estate developer □ Consultant □ Contractor

2. What is your position in a company?

□ Construction/ Project Engineer □ office engineer □ Designer

□ Site Engineer □ Project manager

Other _____

3. How many years of experience do you have?

□ Less than 5 years □ 5-10 years □ More than 10 years

4. What is your highest educational Level?

□ PHD degree □ Master's degree □ First degree □ Diploma

Section II: -Awareness and preferences of prefabrication technology

5. Do you have any idea about prefabrication construction?

□ Yes □ No

6. In your opinion, are the following factors benefits of using prefabricated structural elements than in-situ method?

Benefits	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5
Minimizing of quality problems					
Minimizing of work place hazard					
It takes shorter time					
Minimizing of material wastage					
Minimizing of overhead cost					
Low maintenance cost					
It need less work place					
Easy HR management					
No false work needed					
It need less supervision					

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7. By your opinion, what are shortcomings of using prefabricated structural elements?

Factors	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5
Not easily transported					
It may face connection problem					
It is not flexible with design					
It need more expensive machinery					

If other, please specify: _____
_____.

8. If you get equal chance do you prefer using prefabricated construction method to cast in situ method?

□ Yes □ No

9. Do you know any prefabrication plant of concrete structural element in Addis Ababa?

□ Yes □ No □ yes but not the capacity

Section III: -Application of Prefabricated Concrete Structural Elements to Real Estate Construction in Addis Ababa.

10. Do you have any work experience on prefabricated construction method?

□ Yes □ Yes, but not on real estate □ No

11. To your knowledge, does your company have any work experience on using prefabricated structural elements during real estate construction?

□ Yes □ No □ I don't know

12. If your answer for question No 11 is yes, how many projects are they?

□ 1-2 □ 3-5 □ Above 5

13. As a company does you have any plan to establish prefabrication plant?

□ Yes, as short-term plan □ not at all

□ Yes, as a long-term plan.

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- If your Answer is not at all please specify your reason: _-

_____

_____.

Section IV: -Challenges to Use Prefabricated Concrete Structural Elements to Real Estate Construction in Addis Ababa

14. By your opinion to what extent do the following factors affect the use of prefabricated structural elements in Addis Ababa real estate construction?

Factors	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	2	3	4	5
Shortage of skilled man power on the area					
Shortage of supply of prefabricated elements					
Lack of information about the existing potential.					
Lack of awareness about the technology					
Lack willingness of professionals					

If other, please specify: _____
_____
_____.

15. By your opinion which firms have more potential to improve the application of prefabrication technology in real estate construction of Addis Ababa?

Firms	Negligible	Low	Moderate	High	Very high
	1	2	3	4	5
Contractor					
Real estate Developers					
Designers					
Client					

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Appendix B –Interview Questions

Section I: -Interview Questions to Prefabricated Building Parts Production Enterprise (PBPPE) Staff Members

1. Do you have any customer of real estate developer or real estate contractor?
2. If your answer is no, do you take any action to get customer from the area?
3. By your opinion, what is the major challenge to use prefabricated element for real estate construction in Addis Ababa?
4. What is your future plan to improve technology and your target area?
5. In your opinion, does PBPPE need any major renovations?

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Appendix C- Analysis of importance index and rank of integration problems by different parties

Table A. Analysis of importance index and rank of advantages prefabrication technology by real estate developer

Advantages	RII	Rank
It takes shorter time	0.98	1
Minimize material wastage	0.96	2
Minimize quality problems	0.96	2
Minimize overhead cost	0.93	3
Minimize work place hazard	0.92	4
Easy HR management	0.92	4
Low maintenance cost	0.88	5

Table B. Analysis of importance index and rank of advantages prefabrication technology by contractor

Advantages	RII	Rank
Minimize material wastage	0.99	1
Minimize quality problems	0.96	2
Minimize overhead cost	0.95	3
It takes shorter time	0.95	3
Minimize work place hazard	0.91	4
Easy HR management	0.91	4
Low maintenance cost	0.88	5

Table C. Analysis of importance index and rank of advantages prefabrication technology by consultant

Advantages	RII	Rank
Minimize quality problems	0.98	1
It takes shorter time	0.97	2
Minimize work place hazard	0.95	3
Minimize material wastage	0.95	3

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Advantages	RII	Rank
Minimize overhead cost	0.93	4
Easy HR management	0.93	4
Low maintenance cost	0.89	5

Table D. Analysis of importance index and rank of shortcoming of using prefabricated technology by real estate developer

shortcomings	RII	Rank
It is not flexible with design	0.96	1
Not easily transported	0.96	1
It may face connection problem	0.93	2
It need more expensive machinery	0.90	3

Table E. Analysis of importance index and rank shortcoming of using prefabrication technology ranked by Contractor

shortcomings	RII	Rank
It is not flexible with design	0.95	1
Not easily transported	0.94	2
It may face connection problem	0.94	2
It need more expensive machinery	0.91	3

Table E. Analysis of importance index and rank shortcoming of using prefabricated elements ranked by consultant

shortcomings	RII	Rank
It is not flexible with design	0.95	1
Not easily transported	0.94	2
It may face connection problem	0.92	3
It need more expensive machinery	0.92	3

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Table G. Analysis of importance index and rank of challenges to apply prefabricate structural elements by real estate developer

Factors	RII	Rank
Shortage of supply of prefabricated elements	0.97	1
Lack of information about the existing potential	0.97	1
Shortage skilled man power on the area	0.90	2
Lack of willingness of professional	0.82	3

Table H. Analysis of importance index and rank of challenges to apply prefabricate structural elements by contractor

Factors	RII	Rank
Shortage of supply of prefabricated elements	0.95	1
Lack of information about the existing potential	0.92	2
Shortage skilled man power on the area	0.88	3
Lack of willingness of professional	0.86	4

Table I. Analysis of importance index and rank of challenges to apply prefabricate structural elements ranked by consultant.

Factors	RII	Rank
Shortage of supply of prefabricated elements	0.96	1
Lack of information about the existing potential	0.96	1
Shortage skilled man power on the area	0.89	2
Lack of willingness of professional	0.89	2

Table J. Analysis of importance index and rank of most influential firms on improvements of prefabrication technology by real estate developer

Factors	RII	Rank
Government	0.97	1
Real estate Developers	0.94	2
Designers	0.90	3
Contractor	0.80	4
Client	0.43	5

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Table K. Analysis of importance index and rank of most influential firms on improvements of prefabrication technology by consultant

Factors	RII	Rank
Government	0.98	1
Real estate Developers	0.94	2
Designers	0.89	3
Contractor	0.79	4
Client	0.48	5

Table I. Analysis of importance index and rank of most influential firms on improvements of prefabrication technology by contractor

Factors	RII	Rank
Government	0.98	1
Real estate Developers	0.95	2
Designers	0.88	3
Contractor	0.7	4
Client	0.5	5

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Appendix D- Analysis of Correlation coefficient between different respondent parties

Table A. Analysis of correlation coefficient between real estate developer and Contractor on advantage of prefabrication technology

No	Advantages	Rank by Real Estate Developer	Rank by Contractor	Rd – Cont.	d^2
1	It takes shorter time	1	3	- 2.00	4
2	Minimize material wastage	2	1	1.00	1
3	Minimize quality problems	2	2	-	0
4	Minimize overhead cost	3	3	-	0
5	Minimize work place hazard	4	4	-	0
6	Easy HR management	4	4	-	0
7	Low maintenance cost	5	5	-	0
				$\sum d^2$	5
				n=	7
	$\rho = 1 - \frac{6\sum d^2}{n(n^2-1)}$				0.91

Rd= Real estate developer, Con.t= Contractor

Table B. Analysis of correlation coefficient between real estate developer and consultant on advantages of prefabrication technology

No	Advantages	Rank by Real Estate Developer	Rank by Consultant	Rd - Cons	d^2
1	It takes shorter time	1	2	- 1.00	1
2	Minimize material wastage	2	2	- 1.00	1
3	Minimize quality problems	2	1	1.00	1
4	Minimize overhead cost	3	4	- 1.00	1
5	Minimize work place hazard	4	4	-	0
6	Easy HR management	4	5	- 1.00	1
7	Low maintenance cost	5	5	-	0
				$\sum d^2$=	5
				n=	7
			$\rho = 1 - \frac{6\sum d^2}{n(n^2-1)}$		0.91

Rd= Real estate developer, Cons= Consultant

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Table C. Analysis of correlation coefficient between real estate developer and consultant on advantages of prefabrication technology

No	Advantages	Rank by Contractor	Rank by Consultant	Cont.-Cons	d^2
1	It takes shorter time	2	2	0	0
2	Minimize material wastage	1	3	- 2.00	4
3	Minimize quality problems	2	1	1.00	1
4	Minimize overhead cost	3	4	- 1.00	1
5	Minimize work place hazard	4	3	1.00	1
6	Easy HR management	4	4	-	0
7	Low maintenance cost	5	5	-	0
				$\sum d^2=$	7
				n=	7
				$\rho = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$	0.88

Cont.= Contractor, Cons= Consultant

Table D. Analysis of correlation coefficient between real estate developer and contractor on shortcomings precreation technology

No	Advantages	Rank by Real Estate Developer	Rank by Contractor	Rd-Con	d^2
1	It is not flexible with design	1	1	-	
2	Not easily transported	1	2	1.00	1
3	It may face connection problem	2	2	-	
4	It need more expensive machinery	3	3	-	
				$\sum d^2=$	1
				n=	4
				$\rho = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$	0.91

Rd= Real estate developer, Cont.= Contractor

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Table E. Analysis of correlation coefficient between real estate developer and consultant on shortcomings precreation technology

No	Advantages	Rank by Real Estate	Rank by Consultant	Rd - cons	d^2
1	It is not flexible with design	1	1	-	
2	Not easily transported	1	2	- 1.00	1
3	It may face connection problem	2	3	- 1.00	1
4	It need more expensive machinery	3	3	-	
				$\sum d^2=$	2
				n=	4
				$\rho = 1 - \frac{6\sum d^2}{n(n^2-1)}$	0.80

Rd= Real estate developer, Cons= Consultant

Table E. Analysis of correlation coefficient between contractor and consultant on shortcomings precreation technology

No	Advantages	Rank by Contractor	Rank by Consultant	Cont. -Cons	d^2
1	It is not flexible with design	1	1	-	
2	Not easily transported	2	2	-	0
3	It may face connection problem	3	3	-	0
4	It need more expensive machinery	4	3	1.00	1
				$\sum d^2=$	1
				n=	4
				$\rho = 1 - \frac{6\sum d^2}{n(n^2-1)}$	0.90

Cont.=Contractor, Cons= Consultant

Table F. Analysis of correlation coefficient between real estate developer and contractor on challenges of using prefabricated concrete structural elements in Addis Ababa real estate construction

No	Advantages	**Rank by Real Estate Developer**	**Rank by Contractor**	**Rd – Cont.**	**d^2**
1	Shortage of supply of prefabricated elements	1	1	-	
2	Lack of information about the existing potential	1	2	- 1.00	1
3	Shortage skilled man power on the area	2	3	- 1.00	1
4	Lack of willingness of professional	3	4	- 1.00	1
				$\sum d^2=$	3
				n=	4
				$\rho = 1 - \frac{6\sum d^2}{n(n^2-1)}$	0.70

Rd= Real estate developer, Cont.= Contractor

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Table G. Analysis of correlation coefficient between real estate developer and consultant on challenges of using prefabricated concrete structural elements in Addis Ababa real estate construction

No	Advantages	**Rank by Real Estate Developer**	**Rank by Consultant**	**Rd-Cons**	**d^2**
1	Shortage of supply of prefabricated elements	1	1	-	
2	Lack of information about the existing potential	1	1		
3	Shortage skilled man power on the area	2	2	-	
4	Lack of willingness of professional	3	2	1.00	1
				$\sum d^2=$	1
				n=	4
				$\rho= 1 - \frac{6\sum d^2}{n(n^2-1)}$	0.90

Rd= Real estate developer, Cons= Consultant

Table H. Analysis of correlation coefficient between contractor and consultant on challenges of using prefabricated concrete structural elements in Addis Ababa real estate construction

No	Advantages	Rank by Contractor	Rank by Consultant	Cont.—Cons	d^2
1	Shortage of supply of prefabricated elements	1	1	-	0
2	Lack of information about the existing potential	2	1	1.00	1
3	Shortage skilled man power on the area	3	2	1.00	1
4	Lack of willingness of professional	4	2	2.00	4
				$\sum d^2=$	6
				n=	4
				$\rho= 1 - \frac{6\sum d^2}{n(n^2-1)}$	0.40

Cont.= Contractor, Cons= Consultant

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Table I. Analysis of correlation coefficient between real estate developers and contractor on most potential parties to improve prefabrication technology

No	Advantages	Rank by Real Estate Developer	Rank by Contractor	Rd-Cont.	d^2
1	Government	1	1	-	0
2	Real estate Developers	2	2	-	0
3	Designers	3	3	-	0
4	Contractor	4	4	-	0
5	Client	5	5	-	0
				$\sum d^2=$	0
				n=	5
				$\rho = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$	1

Rd= Real estate developer, Cont.= Contractor

Table J. Analysis of correlation coefficient between real estate developers and consultant on most potential parties to improve prefabrication technology

	Advantages	Rank by Real Estate Developer	Rank by Contractor	Rd- Cons	d^2
1	Government	1	1	-	0
2	Real estate Developers	2	2	-	0
3	Designers	3	3	-	0
4	Contractor	4	4	-	0
5	Client	5	5	-	0
				$\sum d^2=$	0
				n=	5
				$\rho = 1 - \frac{6\Sigma d^2}{n(n^2-1)}$	1

Rd= Real estate developer, Cons= Consultant

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Table J. Analysis of correlation coefficient between contractor and consultant on most potential parties to improve prefabrication technology

	Advantages	Rank by Real Estate Developer	Rank by Contractor	Cont. - Cons	d2
1	Government	1	1	-	0
2	Real estate Developers	2	2	-	0
3	Designers	3	3	-	0
4	Contractor	4	4	-	0
5	Client	5	5		0
				$\sum d^2$=	0
				n=	5
				$\rho = 1 - \frac{6\sum d^2}{n(n^2-1)}$	1

Cont.= Contractor, Cons= Consultant